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"Sp." Elong. 1881.	h	"Inf." Conj.	h	"Nf." Elong.	h	"Sup." Conj.	h
Feb. 6	8·5	Feb. 7	19·7	Feb. 9	7·0	Feb. 10	18·3
12	5·5	13	16·8	15	4·0	16	15·3
18	2·5	19	13·8	21	1·1	22	12·3
23	23·6	25	10·8	26	22·1	28	9·3

Addition to the Ephemeris for Physical Observatious of Jupiter.

By A. Marth, Esq.

Though the Ephemeris published on pp. 416–418 of the *Monthly Notices* contains the data necessary for the reductions of observations, it gives them only so far as they do not involve an assumed value of the planet's ellipticity, and supplementary computations are consequently needed.

Bessel has treated the questions connected with observations of an incompletely illuminated planetary disk in the sixth paper of his *Astron. Untersuchungen*, but he considers only observations made with a heliometer or double-image micrometer, so that some additions referring to observations made by means of webs are required.

If $e = \sin \varepsilon_0$ is the eccentricity of the planet's spheroidal surface or $\cos \varepsilon_0$ the proportion of the polar axis to the equatorial diameter, P the angle of position of the polar axis, B the latitude of the earth above the planet's equator, and $\sin \varepsilon = \sin \varepsilon_0 \cos B$, the outline of the apparent planetary disk will be an ellipse, the minor axis of which, in position-angle P, is $= 2a \cos \varepsilon$, if the major axis or the equatorial diameter is $= 2a$, and the radius of the disk in position-angle p will be

$$= a \cos \epsilon', \text{ if } \tan \epsilon' = \tan \epsilon \,.\, \cos (p - \mathrm{P}).$$

Provided that the limit of illumination passes through those points on the planet's surface which have the Sun's centre in their true horizon, the projection of the limit of illumination upon the disk will be an ellipse, the radius of which in position-angle p is $= a \cos \varepsilon' \cos d'$, if

$$\tan \psi = \tan (p - \mathrm{P}) \cos \epsilon, \quad \text{and} \quad \tan d' = \tan d \cos (\psi - w),$$

where d and w have the same significance as in Bessel's paper.

The visible disk of the planet is generally composed of two half-ellipses, the direction of their common diameter or of the line of cusps being in position-angle

$$\mathrm{P} + w_1 \mp 90^\circ, \quad \text{where} \quad \tan w_1 = \tan w \cos \epsilon.$$

The limit of illumination is visible in the two quadrants adjoin-

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ing the position-angle $P + w_1$, while the rim of the disk is visible in the two opposite quadrants adjoining the position-angle

$$P + w_1 + 180^\circ.$$

A web or a line being moved to or from the centre of the disk in the direction of the position-angle p or $p + 180^\circ$ will be a tangent to the rim of the disk when its distance from the centre is

$$= a \sqrt{1 - \sin^2 \epsilon \cos^2 (p - P)};$$

and it will be a tangent to the curve formed by the limit of illumination when its distance from the centre is

$$= a \sqrt{1 - \sin^2 \epsilon \cos^2 (p - P)} \,.\, \sqrt{1 - \sin^2 d \cos^2 (p_1 - w)},$$

where

$$\tan p_1 = \tan (p - P) \sec \epsilon.$$

Hence, by putting

$$\sin \nu = \sin \epsilon \cos (p - P) \quad \text{and}$$
$$\sin \delta = \sin d \cos (p_1 - w),$$

the distance of the two tangents which touch the two curves and enclose the visible disk is found

$$= 2a \cos \nu \cos^2 \frac{1}{2} \delta, \quad \text{or}$$

minus the defect of illumination, $2a \cos \nu \sin^2 \frac{1}{2} \delta$,

$$= 2a \cos \nu.$$

In observations of right ascension and declination the values of p are

$$p = 90^\circ \quad \text{and} \quad p = 0^\circ.$$

Hence, by putting

$$\begin{aligned} \sin \nu &= \sin \epsilon \sin P, & \text{and} \quad \sin \nu' &= \sin \epsilon \cos P, \\ \tan P' &= \tan P \cos \epsilon, & \tan P' &= \tan P \sec \epsilon, \\ \sin \delta &= \sin d \sin (P' + w), & \sin \delta' &= \sin d \cos (P' + w), \end{aligned}$$

the differences of the limbs in right ascension and declination are found to be

$$\frac{2a \cos \nu}{15 \cos D} \,.\, \cos^2 \frac{1}{2} \delta \quad \text{and} \quad 2a \cos \nu' \,.\, \cos^2 \frac{1}{2} \delta'$$

(D being the planet's declination), or

$$\frac{2a \cos \nu}{15 \cos D} \quad \text{and} \quad 2a \cos \nu'$$

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when corrected for the defects of illumination

$$\frac{2a\cos\nu}{15\cos D}\,.\,\sin^2\frac{1}{2}\,\delta \quad\text{and}\quad 2a\cos\nu'\,.\,\sin^2\frac{1}{2}\,\delta'.$$

These latter values will be found further on in the table.

In case the declination-webs are not perpendicular upon the transit-webs, but are so inclined that the corresponding p is not $=0°$, but $=i$, the values

$$\sin\nu' = \sin\epsilon\cos(P-i)$$

and

$$\tan P'' = \tan(P-i)\sec\epsilon$$

must be substituted for those before given.

In measurements of the equatorial and polar diameters

$$p \text{ is } = P+90 \text{ and } = P.$$

Hence, if

$$\sin\delta = \sin d\sin w \quad\text{and}$$
$$\sin\delta' = \sin d\cos w,$$

the measured distances are

$$2a\cos^2\frac{1}{2}\,\delta \quad\text{and}\quad 2a\cos\epsilon\cos^2\frac{1}{2}\,\delta',$$

or the defect of illumination of the equatorial diameter

$$2a \text{ is } 2a\sin^2\frac{1}{2}\,\delta,$$

and that of the polar diameter

$$2a\cos\epsilon \text{ is } 2a\cos\epsilon\sin^2\frac{1}{2}\delta'.$$

If, in observing a planetary disk with a double-image micrometer, the images are separated in the direction p, the amount of separation which produces external contact of the two curves is, according to Bessel's investigation,

$$= 2a\sqrt{1-\sin^2\epsilon\cos^2\psi}\,.\left(1-\sin^2\frac{1}{2}\,d\cos^2(\psi-w)\right),$$

where

$$\tan\psi = \tan(p-P)\cos\epsilon.$$

Hence measurements in the two directions for which $\psi-w$ is $=0°$ and $=90°$, and which have been specially suggested, would give values of

$$2a\cos^2\frac{1}{2}\,d\,.\,\sqrt{1-\sin^2\epsilon\cos^2 w}$$

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and of

$$2a\sqrt{1-\sin^2\epsilon\sin^2 w}.$$

The corresponding position-angles are

$$P + w' \quad\text{and}\quad P + w_1 \pm 90°,$$

where

$$\tan w' = \tan w \sec\epsilon, \quad\text{and}\quad \tan w_1 = \tan w \cos\epsilon,$$

and these angles would have to be known beforehand. The latter direction is that of the line of cusps.

Double-image measurements in the directions P+90 and P of the chief axes give values of

$$2a\left(1-\sin^2\frac{1}{2}d\sin^2 w\right)$$

and of

$$2a\cos\epsilon\left(1-\sin^2\frac{1}{2}d\cos^2 w\right)$$

and it appears preferable to take the measures in these directions.

In the following Ephemeris, which will require little further explanation, I give now some additional data for the proper reduction of observations. The defect of illumination of the polar diameter is insensible, and that of the equatorial diameter does not differ sensibly from the "greatest phase" given on page 416 ff.

The assumed value of *Jupiter's* equatorial diameter is still Bessel's 37″·60 at the distance 5·20273, corresponding to the semi-diameter 97″·81 at the distance 1. The assumed value of cos ϵ_0 or of the proportion of the polar axis to the equatorial diameter is 0·9363. It would be very desirable that these values should be substantially improved by modern observations; but, of course, only the best observations would serve the purpose.

The last column of the Ephemeris gives the elongations O−L of the point O of *Jupiter's* vernal equinox from the point L in the plane of his equator, which is in superior conjunction in reference to the Earth.

Greenw. Noon 1880		Polar Diam.	Difference between limbs.		Defect of illumination.		d.	w.	O−L.
			in A.R.	in Decl.	in A.R.	in Decl.			
June	18	35″·42	2″·505	35″·84	prec. l.	south l.	11°·25	271°·34	119°·638
	23	35·94	2·543	36·36	0″·022	0″·06	11·49	271·42	118·939
	28	36·48	2·582	36·90	·023	·06	11·67	271·50	118·299
July	3	37·04	2·623	37·47	·024	·06	11·79	271·59	117·721
	8	37·62	2·665	38·06	·025	·06	11·85	271·68	117·208
	13	38·22	2·708	38·66	·025	·07	11·84	271·77	116·764
	18	38·84	2·753	39·28	·025	·06	11·75	271·88	116·391

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Greenw. Noon		Polar Diam.	Difference between limbs. in A.R.	Difference between limbs. in Decl.	Defect of illumination. in A.R.	Defect of illumination. in Decl.	*d.*	*w.*	O—L.
1880.		″	″	″	″	″	°	°	°
July	23	39·47	2·798	39·92	·025	·06	11·59	271·99	116·092
	28	40·11	2·844	40·57	·024	·06	11·35	272·12	115·872
Aug.	2	40·76	2·890	41·22	·024	·06	11·04	272·26	115·732
	7	41·41	2·936	41·88	·022	·05	10·64	272·42	115·673
	12	42·05	2·982	42·53	·021	·05	10·16	272·61	115·697
	17	42·68	3·026	43·16	·019	·04	9·59	272·82	115·804
	22	43·28	3·068	43·77	·017	·04	8·95	273·08	115·993
	27	43·86	3·108	44·36	·014	·03	8·23	273·38	116·262
Sept.	1	44·40	3·145	44·90	·012	·03	7·42	273·74	116·607
	6	44·89	3·178	45·40	·009	·02	6·54	274·20	117·025
	11	45·32	3·208	45·84	·007	·01	5·60	274·84	117·510
	16	45·69	3·233	46·22	·005	·01	4·60	275·78	118·052
	21	45·99	3·252	46·52	·003	·00	3·56	277·14	118·643
	26	46·20	3·266	46·74	·001	·00	2·48	279·72	119·272
Oct.	1	46·33	3·274	46·88	·000	·00	1·39	286·39	119·929
	6	46·38	3·276	46·93	foll l.	north l.	0·42	329·70	120·601
	11	46·33	3·271	46·89	·000	·00	0·98	70·95	121·275
	16	46·20	3·260	46·75	·001	·01	2·07	82·24	121·937
	21	45·98	3·244	46·53	·002	·01	3·15	85·76	122·575
	26	45·67	3·222	46·23	·004	·01	4·21	87·47	123·177
	31	45·29	3·194	45·85	·005	·02	5·22	88·53	123·732
Nov.	5	44·85	3·162	45·40	·008	·03	6·17	89·25	124·229
	10	44·34	3·126	44·89	·010	·03	7·06	89·77	124·660
	15	43·78	3·086	44·33	·012	·04	7·87	90·17	125·017
	20	43·19	3·044	43·72	·015	·05	8·61	90·49	125·295
	25	42·56	3·000	43·09	·017	·05	9·27	90·76	125·491
	30	41·91	2·954	42·43	·018	·06	9·83	90·98	125·601
Dec.	5	41·25	2·907	41·76	·020	·06	10·31	91·17	125·624
	10	40·58	2·860	41·08	·021	·06	10·71	91·34	125·559
	15	39·91	2·813	40·40	·022	·07	11·02	91·48	125·408
	20	39·24	2·766	39·73	·023	·07	11·24	91·62	125·173
	25	38·59	2·721	39·07	·023	·07	11·38	91·74	124·856
	30	37·95	2·676	38·42	·023	·06	11·45	91·85	124·460
1881.									
Jan.	4	37·33	2·633	37·79	·023	·06	11·44	91·96	123·987
	9	36·74	2·592	37·19	·022	·06	11·35	92·05	123·443
	14	36·17	2·553	36·61	·021	·06	11·20	92·14	122·831
	19	35·62	2·515	36·05	·020	·05	10·98	92·22	122·155
	24	35·10	2·480	35·53	·019	·05	10·70	92·30	121·419

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Greenw. Noon		Polar Diam.	Difference between limbs.		Defect of illumination.		d.	w.	O−L.
			in A.R.	in Decl.	in A.R.	in Decl.			
1881									
Jan.	29	34″·62	2″·447	35″·03	″·017	″·05	10°·37	92°·39	120°·627
Feb.	3	34·16	2·416	34·56	·016	·04	9·99	92·48	119·783
	8	33·73	2·387	34·12	·015	·04	9·55	92·57	118·892
	13	33·33	2·360	33·71	·013	·03	9·07	92·67	117·957
	18	32·96	2·336	33·34	·012	·03	8·56	92·77	116·982
	23	32·62	2·314	32·99	·010	·02	8·01	92·89	115·971
	28	32·31	2·294	32·67	0·009	0·02	7·42	93·02	114·927

The inclinations γ and the ascending nodes Γ of the orbits of the four satellites in reference to the plane of *Jupiter's* equator are the following, the nodes being reckoned from O, the point of the vernal equinox of *Jupiter's* northern hemisphere:—

		Sat. I.		Sat. II.		Sat. III.		Sat. IV.	
1880		γ_1	Γ_1	γ_2	Γ_2	γ_3	Γ_3	γ_4	Γ_4
Feb.	14	0°·0103	3°·7	0°·4654	13°·20	0°·1867	265°·97	0°·3272	329°·50
April	14	·0105	1·8	·4665	11·21	·1858	265·64	·3277	329·56
June	13	·0106	0·0	·4676	9·23	·1849	265·31	·3281	329·64
Aug.	12	·0108	358·4	·4687	7·26	·1839	264·99	·3284	329·75
Oct.	11	·0109	356·9	·4697	5·30	·1827	264·66	·3286	329·86
Dec.	10	·0111	355·5	·4708	3·35	·1815	264·33	·3286	329·99
1881									
Feb.	8	·0112	354·2	·4718	1·40	·1802	263·98	·3286	330·13
April	9	0·0112	352·9	0·4727	359·46	0·1789	263·61	0·3284	330·28

If these values of Γ are added to the elongations $O-L$ of the point O from superior conjunction, given in the last column of the preceding table, the angles $\Gamma+O-L$ are the longitudes of the ascending nodes of the orbits reckoned from that line in the plane of the equator which is in superior conjunction in reference to the Earth. Hence the latitudes of the satellites above the plane of *Jupiter's* equator are easily found, if their elongations are known.

I have received from Mr. Trouvelot some observations of passages of the red spot made in 1878. The time of the passage of the preceding end on Sept. 25 is only inferred from an estimate made at $6^h\ 30^m$ Camb. M.T.: "preceding extremity of red spot has passed central meridian 10 or 15 minutes." I retain it, however, in the additional list, and will now also not omit the result of Prof. Pritchett's own inference from his observations made on July 9, 1878, an account of which with an illustration is to be found in *The Observatory*, vol. ii., p. 308. Prof. Pritchett writes:—"I am very sure of the time of the transit of the centre of the spot over the Central Meridian on that day within 10 minutes—it must have occurred between $19^h\ 15^m$ and $19^h\ 25^m$ Gr. M. T."

	Observed Passages.				Corresponding Longitudes.					
					Rot. 870°·60.			Rot. 870°·43.		
1878.	Prec. End. h m	Middle. h m	Foll. End. h m		Prec. End. °	Middle. °	Foll. End. °	Prec. End. °	Middle. °	Foll. End. °
	Pritchett, Glasgow, Missouri.									
July 9	between	19 15	—	Gr.	—	245·6	—	—	324·5	—
		19 25	—	,,	—	251·7	—	—	330·6	—
	Trouvelot, Cambridge, Massachusetts.									
Sept. 25	6 15	—	—	Cambridge	176·9	—	—	242·6	—	—
	6 20	—	—	,,	179·9	—	—	245·6	—	—
30	—	6 35	—	,,	—	221·5	—	—	286·4	—
Oct. 2	—	7 45	—	,,	—	204·8	—	—	269·3	—
Nov. 12	—	—	6 50	,,	—	—	219·3	—	—	276·8
24	6 10	—	—	,,	199·7	—	—	255·2	—	—
29	5 15	—	—	,,	198·2	—	—	252·9	—	—
Dec. 16	—	6 35	—	,,	—	210·1	—	—	261·9	—
23	—	5 33	—	,,	—	217·6	—	—	268·2	—
28	—	4 45	—	,,	—	220·3	—	—	270·1	—

I can also add the first observation made by Prof. Pritchett since *Jupiter's* reappearance in the present season.

1880	Prec. End.	Middle.	Foll. End.		Prec. End.	Middle.	Foll. End.	Prec. End.	Middle.	Foll. End.
May 25	—	23 12	—	Gr.	—	306·6	—	—	268·8	—

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Prof. Pritchett writes:—"The observation was made after sunrise, but was entirely satisfactory. The spot has changed very little since the autumn of last year."

It is to be hoped that proper observations have been made and may soon be forthcoming to clear up the early history of the spot in 1878.

An Examination of the Double-Star Measures of the Bedford Catalogue. By S. W. Burnham, Esq.

The micrometrical measures of double stars by Admiral Smyth, recorded in the "Bedford Catalogue," may, for the purpose of this examination be considered in two distinct classes, which are unlike in respect to the character of the measures and the order of stars observed. This classification is based wholly upon the fact whether or not other measures of these stars were made prior to 1844.

Class I. Double stars accurately measured by Struve, Sir William Herschel, South, and others, before the epoch of Smyth.

Class II. Double stars, and stars with distinct companions, which had not been carefully measured by any other observer up to the time of the publication of the "Cycle of Celestial Objects."

A cursory examination will show that the quality of the measures as to accuracy is very different. The measures of Class I. are, in the main, uniformly correct. This is shown by comparing them with earlier and later measures by other observers which are known to be correct. The only exceptions are in instances when the prior observations were palpably erroneous. In such cases the Cycle measures are equally in error.

The measures of Class II. are quite as uniformly either roughly approximate or grossly incorrect. The greater portion of the objects in this class are not double stars in any proper sense of the term, but are simply small stars in the same field with larger and generally prominent naked-eye stars. The distances are very great, and the objects themselves are devoid of any interest to a double-star observer. Some of the stars catalogued by Sir John Herschel which have been measured by Smyth belong to this class, as the distances were all estimated by Herschel, and the angles generally given from single readings. A few of the Struve stars, not measured at Dorpat, and rejected in *Mensuræ Micrometricæ*, are also thus inserted. The larger part of the objects in this class would be of easy measurement with a 5·9-inch aperture, and much easier than many in class I.

My attention was first called to the doubtful accuracy of the observations of the Bedford Catalogue by communications relating to the alleged disappearance of the companions to certain